MALE REPRODUCTIVE CYCLE IN SOME INDIAN BATS[1]

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(*With a text-figure*)

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This report embodies observations on the male sex-cycle in twelve species of Indian bats included in eight families. Except *Taphozous longimanus, Pipistrellus dormeri* and *P. mimus,* all the species breed in a sharply defined season. Most of them have a boreal type of sexual rhythm. *Pipistrellus ceylonicus chrysothrix* breeds in the rainy season. The exceptional three species mentioned above breed throughout the year. In all species the male reproductive cycle is either synchronised or adapted to the female sexual cycle.

Introduction

Although India has a rich chiropteran fauna with nearly a hundred species incorporated in nine families, our knowledge about Indian bats is restricted to the study of the general nature of the breeding habits of only the females of a few species. Even from these few studies it is evident that these animals exhibit interesting reproductive strategies. Some information concerning the reproduction in males is available with respect to two megachiropteran species, namely *Cynopterus sphinx* (Sandhu and Gopalakrishna 1984) and *Rousettus leschenaulti* (Gopalakrishna *et al.* 1993) and four microchiropteran species, namely *Scotophilus temmincki* (Gopalakrishna 1948), *Rhinopoma kinneari* (Kumar 1965), *Hipposideros fulvus* and *Pipistrellus ceylonicus chrysothrix* (Gopalakrishna *et al.* 1992, Gopalakrishna and Badwaik 1993). The present study on the male reproductive behaviour of some Indian bats was undertaken not only because there is no information on the male sexual cycle of these species but to find out how the males have adapted to different patterns of reproduction in the females of these species.

Materials and Methods

The reproductive cycle in males of the following species is reported: *Taphozous longimanus* (Emballonuridae), *Megaderma lyra lyra* (Megadermatidae), *Rhinolophus rouxi* (Rhinolophidae), *Hipposideros speoris* (Hipposideridae), *Pipistrellus dormeri, P. mimus mimus, Scotophilus heathi* (all Vespertilionidae) and *Miniopterus schreibersii fuliginosus* (Miniopteridae — Gopalakrishna and Karim 1980) are studied for the first time. Additional information on the male reproductive cycle of *Rousettus leschenaulti* (Pteropodidae), *Rhinopoma microphyllum* (Rhinopomatidae), *Hipposideros fulvus fulvus* (Hipposideridae) and *Pipistrellus ceylonicus chrysothrix* (Vespertilionidae) is also included here. Thus, representatives of all the families available in India except Molossidae are included in the present study. Male specimens of all these species were collected periodically from 5th April, 1981 to 4th March 1987 such that every calendar month is represented by one collection or more. Most of the specimens were collected from Vidarbha, Marathwada and South-Western Madhya Pradesh. All specimens of *Miniopterus schreibersii fuliginosus* were collected at Mahabaleshwar in Western Ghats. A few specimens of *Megaderma lyra lyra* were also collected at and around Bangalore and Mysore in South India and at and around Agra in North India. Table 1 indicates the number of adult male specimens examined for this report during each calendar month. Although specimens of *Hipposideros speoris* were collected from several

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TABLE 1

THE NUMBER OF ADULT MALE SPECIMENS EXAMINED DURING DIFFERENT MONTHS OF THE YEAR (1981-1987)

No.	Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1.	*Rousettus leschenaulti*	8	3	4	5	3	2	2	4	4	2	4	4	45
2.	*Taphozous longimanus*	2	2	4	2	1	3	2	3	2	2	1	2	26
3.	*Rhinopoma m. kinneari*	—	—	4	7	1	1	4	—	4	—	—	—	21
4.	*Megaderma lyra lyra*	5	6	14	4	3	4	9	7	4	4	8	3	71
5.	*Rhinolophus rouxi*	2	2	3	4	2	1	1	4	3	4	4	5	35
6.	*Hipposideros f. fulvus*	7	7	2	8	5	5	7	4	3	6	5	6	65
7.	*Hipposideros speoris*	13	8	5	6	8	5	8	8	5	6	6	8	86
8.	*Pipistrellus c. chrysothrix*	6	5	3	7	9	12	10	7	6	4	5	5	79
9.	*Pipistrellus dormeri*	3	4	4	5	7	6	3	4	3	4	3	4	50
10.	*Pipistrellus m. mimus*	11	6	7	13	3	2	1	4	4	3	2	5	61
11.	*Scotophilus heathi*	3	10	9	3	4	3	3	6	4	2	8	12	67
12.	*Miniopterus s. fuliginosus*	2	7	10	16	12	10	3	2	5	14	11	4	96

localities, the present report embodies descriptions of specimens collected only at Chandrapur (19° 57' N, 79° 21' E) in Eastern Vidarbha. The male cycle of this species in other parts of peninsular India has already been reported (Brosset 1962, Gopalakrishna *et al.* 1991). The specimens were killed by chloroform, their genitalia dissected out and fixed in alcoholic Bouin's fluid. Microscopic examination of the testis and the accessory glands were made on serially sectioned tissues stained with Harris' or Erlich's haematoxylin and counterstained with eosin. A few sections of the accessory glands from each series of sections were also stained by the per-iodic acid-Schiff procedure (Pearse 1968). The present report is based on the examination of the testes and accessory glands of only adult specimens.

Observations and Discussion

Figure 1 is a schematic representation to indicate the periods of the year when the testis exhibits spermatogenesis and the male accessory glands are active in the species studied here. The figure has been drawn after determining sexual maturity of the specimens by microscopic examination of the structure of the testis and accessory glands of the specimens. The data concerning the season of pregnancy of the various species are taken from earlier reports and are also included in the figure for easy comparison of the reproductive rhythm in both sexes. The following conclusions can be drawn from the figure:

1. In all the species studied here the onset of spermatogenesis and secretory activity in the accessory glands occur nearly synchronously, and, in all but *Hipposideros speoris,* the activity of the two components of the male reproductive system also come to cessation nearly synchronously. In *Hipposideros speoris,* however, the secretory activity in the accessory glands continue to remain at peak level for nearly 14 weeks after the cessation of spermatogenesis in the testis.

2. Sexually active males and pregnant females occur throughout the year in *Taphozous longimanus, Pipistrellus dormeri* and *P. mimus mimus* (*P. dormeri* has been omitted from the figure since its reproductive behaviour in both sexes is exactly similar to that in the other two species). Evidently, these species breed all the year round. Earlier reports on the breeding behaviour of the females of these species (Gopalakrishna 1954, 1955; Gopalakrishna *et al.* 1975, Madhavan 1979) have shown that each female of these species experiences more than one pregnancy during each year as revealed by the fact that females in lactation, and which were also carrying early pregnancy, were available during all the months of the year. This is a strong circumstantial evidence to indicate that each female comes to oestrus within a few days after parturition, and, hence, they may experience several pregnancies occurring in quick succession during each year. Vigorous spermatogenetic activity occurs in the testis of adult specimens during all the months of the year. The accessory glands are also in a high state of secretory activity throughout the year. These facts suggest that males of these species are sexually active throughout the year.

3. In *Rousettus leschenaulti* spermatogenesis occurs from the beginning of October to the middle of April with peak activity occurring twice within this period, once during November-December and a second time during March-April. There is a slightly lessened spermatogenetic activity during January and February. The accessory glands exhibit a similar pattern of activity as the testis except that they come to activity in the middle of October — about two weeks later than the testis. The testis and accessory glands are inactive from the middle of April until the following reproductive season. Females of this species experience two pregnancies in quick succession with the lactation period of the first cycle overlapping the early gestation of the second cycle during March and April (Gopalakrishna 1964, Gopalakrishna and Choudhari 1977).

4. In *Megaderma lyra lyra, Rhinolophus rouxi, Hipposideros fulvus* and *Scotophilus heathi* the testes and accessory glands are active during a

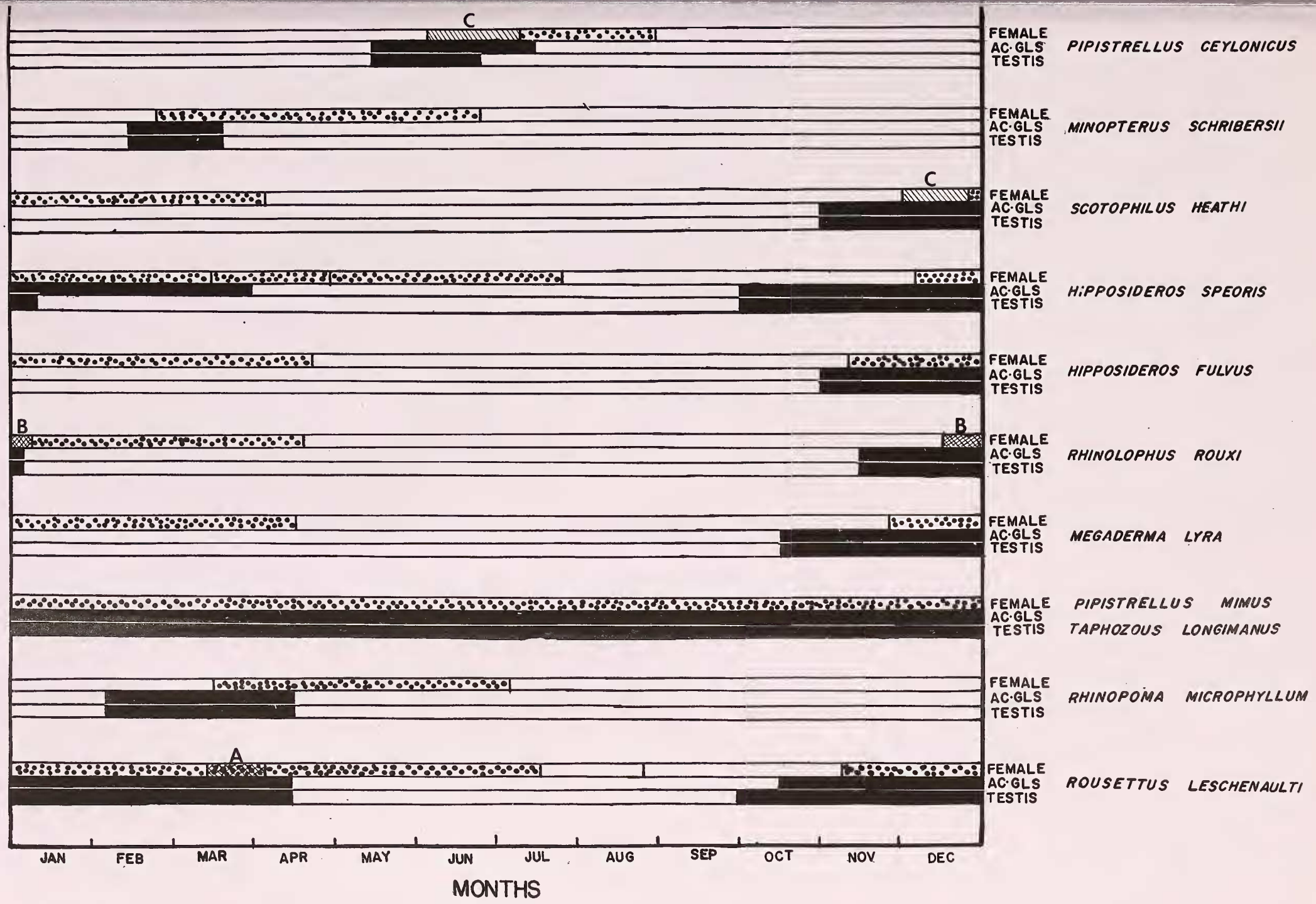

Fig. 1. Schematic representation of the periods of sexual activity in the two sexes in the species studied here. The heavy dark areas indicate the period of sexual activity in the males and the dotted areas indicate the period of sexual activity in the females. A. the period when lactation of the first cycle overlaps the early pregnancy of the second cycle in *Rousettus leschenaulti;* B. Period when there is either delayed implantation or retarded development of the blastocyst in *Rhinolophus rouxi.* C. period when inseminated spermatozoa are stored in the genital tract of the female in *Scotophilus heathi* and *Pipistrellus ceylonicus chrysothrix.*

sharply restricted period, namely from the middle of October to the end of December in *Megaderma,* from the middle of November to about the first week of January in *Rhinolophus,* during November and December in *Hipposideros fulvus fulvus* and *Scotophilus heathi.* In all these species the females come to sexual activity a few weeks later than the males as revealed by the fact that pregnant females were noticed from a date later than the date of onset of activity in the males (Gopalakrishna 1950, Ramakrishna 1951, Ramaswamy 1961, Gopalakrishna and Badwaik 1989, Gopalakrishna and Rao 1977, Madhavan *et al.* 1977, Gopalakrishna and Madhavan 1978, Madhavan 1981). Earlier reports have shown that delayed implantation of the blastocyst (Gopalakrishna and Rao 1977) and retarded early development (Ramakrishna and Rao 1978) occur in *Rhinolophus rouxi* in different parts of India.

In *Scotophilus heathi* (Gopalakrishna and Madhavan 1978, Krishna and Dominic 1978) the inseminated spermatozoa remain viable in the genital tract of the females and fertilise the oocytes released several weeks later. Hence, there is a certain degree of asynchrony between the two sexes in the onset of sexual activity.

5. In *Miniopterus schreibersii fuliginosus* the testes and accessory glands are active for only a short period in the year from the middle of February until the last week of March. Spermatogenetic activity and the secretory activity in the accessory glands occur synchronously. There is a sudden cessation of spermatogenesis and secretory activity in the accessory glands after March. Females are inseminated and conceive in the third week of February and deliver and young ones in the latter half of June (Gopalakrishna *et al.* 1985, personal observations).

6. The testes and accessory glands in *Rhinopoma microphyllum* at Burhanpur (21° 17' N, 76° 16' E) come to activity during the first week of February and remain active until the middle of April, and the males are sexually quiescent during the rest of the year. All adult females in the colony copulate and conceive during the second week of March and deliver the young ones in the first week of July (Badwaik 1991). Kumar (1965), while studying the reproduction in this species at Jodhpur (26° 18' N, 73° 04' E) indicated that fully formed spermatozoa were present within the cauda epididymis and the ampullary glands in varying amounts throughout the year. He further mentioned, "It is not known whether these are functional". The cycle in the female of this species at Jodhpur (Kumar 1965) is nearly similar to that at Burhanpur.

7. In *Pipistrellus ceylonicus chrysothrix* the testes and accessory glands come to activity in the middle of May. While spermatogenesis ceases by the end of the third week of June, the accessory glands continue to be in a state of high secretory activity until the middle of July. Earlier reports on the female reproductive cycle in this species (Madhavan 1971, Gopalakrishna and Madhavan 1977) have shown that copulation occurs during the first two weeks of June and the inseminated spermatozoa remain viable in the female genital tract for several weeks and fertilise the oocytes released in the second week of July.

8. In *Hipposideros speoris* vigorous spermatogenetic activity occurs from October to the first week of January, and the accessory glands come to activity synchronously with spermatogenetis activity. However, the accessory glands continue to maintain a high level of secretory activity until April (Gopalakrishna *et al.* 1992). Further, the cauda epididymis is greatly enlarged and is filled with spermatozoa from November to the end of April even after the cessation of spermatogenesis in the middle of January. Earlier studies on the female sex-cycle of this species at Chandrapur (Gopalakrishna and Bhatia 1983, Gopalakrishna *et al.* 1992) indicated that all parous females conceive in the first week of December, but the first year females conceive as and when they attain sexual maturity any time from January to April. Hence, from January to the last week of July females at different stages of pregnancy were noticed in the colony, and the last delivery occurred on 24th July (the gestation

period being 135 to 140 days). Females in lactation were noticed from May until the last week of September. This species appears to exhibit different types of reproductive patterns at different localities in peninsular India (Brosset 1962, Gopalakrishna *et al.* 1991).

From the foregoing observations it is evident that most species of bats have a highly specific reproductive periodicity, but the precise period of sexual activity varies among different species. Secondly, while most of the species come to sexual activity during November-December (boreal type) a few breed during February-March (austral type). Only *Pipistrellus ceylonicus chrysothrix* is sexually active during May-June. Sexual activity during May-July has been reported in two molossid bats, *Chaerephon plicata* (Gopalakrishna *et al.* 1989) and *Tadarida aegyptiaca* (Gopalakrishna *et al.* 1991) in South Western Madhya Pradesh. The females among the species studied here come to sexual activity a little later in the year than the males. *Rousettus leschenaulti* (Gopalakrishna and Choudhari 1977) appears to incorporate both boreal and austral breeding patterns with the occurrence of two reproductive cycles with a reduced male sexual activity between the two cycles. A similar situation was reported with respect to *Cynopterus sphinx* (Moghe 1956, Sandhu 1984). In *Pipistrellus ceylonicus chrysothrix* (Madhavan 1971, Gopalakrishna and Madhavan 1971) and *Scotophilus heathi* (Gopalakrishna and Madhavan 1978, Madhavan 1981) the inseminated spermatozoa are stored in the genital tract of the female until ovulation takes place.

Hipposideros speoris (at Chandrapur) appears to be unlike all other species because spermatozoa are stored in the cauda epididymis for several days after the cessation of spermatogenesis. From this it is evident that there are at least two separate mechanisms in this species — one which initiates and maintains spermatogenetic activity in the testes and another which triggers and maintains the activity of the accessory glands for a protracted period, and during this period spermatozoa are stored and they remain viable in the cauda epididymis. Evidently, there appears to be a special physiological mechanism by which the chemical medium within the cauda epididymal tubule is maintained in a manner conducive to the long survival of spermatozoa at body temperature.

Conclusions

The examination of even a few species of Indian bats, among the nearly hundred species inhabiting this country, reveals a variety of breeding patterns and adaptations for successful reproduction. The protracted survival of inseminated spermatozoa, which had been noticed in bats inhabiting cold and temperate countries, has been attributed to the long winter hibernation of these bats in the cold countries. But, in a tropical country, where the bats do not hibernate, the survival of inseminated spermatozoa in *Pipistrellus ceylonicus chrysothrix* and *Scotophilus heathi* and stored spermatozoa in the epididymis of *Hipposideros speoris* at body temperate needs explanation. Further, the seasonal climatic changes in the tropical regions are not so pronounced as in the cold and temperate regions. Yet, the facts, that they exhibit a strict reproductive periodicity, and that this varies among different species, demand explanation.

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